

IN THE CLAIMS:

1 1. (Currently Amended) In a file server having a storage operating system, a method for
2 managing storage of data in a plurality of storage devices, each storage device having a
3 plurality of blocks for storing data, comprising:

4 generating block layout information in a file system layer of the storage operating
5 system by determining which blocks within the plurality of blocks are allocated for
6 storing data and which are unallocated;

7 transferring the block layout information from the file system layer to a RAID
8 layer of the storage operating system; ~~and~~

9 responsive to the block layout information, controlling ~~the~~ execution of I/O
10 operations at the RAID layer by identifying a plurality of contiguous blocks on a single
11 storage device within the plurality of blocks for use by each I/O operation so as to
12 substantially maximize chain lengths of read operations for calculation of parity;

13 determining whether a parity subtraction method or a recalculation method
14 requires a fewest number of read operations to calculate parity for the I/O operations;

15 selecting ~~thea~~ parity subtraction method or ~~thea~~ recalculation method for parity
16 calculation based on ~~the-which~~ method ~~that~~ requires ~~thea~~ fewest number of read
17 operations ~~to compute parity for the I/O operations;~~ and

18 responsive to the block layout information and the parity calculation method
19 selected, identifying the contiguous blocks within the plurality of blocks for use by the
20 I/O operations.

1 2. (Currently Amended) A method for managing storage of data in a plurality of storage
2 devices, each comprising a plurality of storage blocks, comprising:

3 generating block layout information;

4 determining whether a first methodology or a second methodology requires a
5 fewest number of read operations to calculate parity; and

6 in response to the block layout information and the determination, controlling
7 execution of I/O operations by identifying a plurality of contiguous storage blocks on a
8 single storage device for use by each I/O operation so as to substantially minimize a ~~the~~

9 number of read operations needed for calculation of error correction parameters across a
10 | stripe disposed among the plurality of storage devices.

1 3. (Original) The method of claim 2 wherein the calculation of error correction
2 parameters comprises the calculation of parity.

1 | 4. (Currently Amended) The method of claim ~~3~~2 wherein the calculation of parity
2 comprises selecting a parity calculation operation from a group consisting of a
3 | subtraction method as the first methodology and a parity re-calculation method as the
4 second methodology.

1 | 5. (Currently Amended) The method of claim 2 wherein the identification of contiguous
2 storage blocks for use in the I/O operation substantially maximizes a chain length by
3 | substantially maximizing ~~the~~a number of blocks having a contiguous physical layout on
4 the single storage device.

1 6. (Currently Amended) The method of claim 2, further comprising:
2 | identifying the contiguous storage blocks for use in the I/O operation so as to
3 substantially maximize the chain length by substantially maximizing ~~the~~a number of
4 | blocks having sequential volume block numbers (VBNs) associated with the plurality of
5 storage blocks.

1 7. (Currently Amended) The method of claim 2, further comprising:
2 | identifying the contiguous storage blocks for use in the I/O operation so as to
3 substantially maximize the chain length by substantially maximizing locality of the
4 | contiguous blocks of the single storage device.

1 | 8. (Currently Amended) The method of claim 2 wherein ~~the~~controlling execution ~~step~~
2 comprises:

3 examining storage blocks to which data is to be written prior to write operations;
4 and
5 ~~selecting one of a plurality of parity calculation methodologies including either,~~
6 ~~a~~the first methodology comprising minimizing a number of blocks read, ~~and or~~
7 ~~a~~the second methodology comprising maximizing chain lengths of blocks read
8 for calculating parity calculation.

1 9. (Currently Amended) The method of claim 8, wherein ~~the~~ controlling execution ~~step~~
2 further comprises:

3 implementing selection of the parity calculation methodology responsive to the
4 block layout information; ~~and~~

5 wherein, if the selection constitutes ~~substantially~~ minimizing the number of
6 blocks read,

7 determining on a stripe-by-stripe basis whether to calculate parity based on a
8 subtraction method or a recalculation method,

9 performing any appropriate read operations to support the method selected, and
10 calculating parity responsive to the number of blocks read and the data to be
11 written; and

12 wherein, if the selection constitutes ~~substantially~~ maximizing chain lengths of
13 blocks read,

14 deciding which storage blocks to read to ~~substantially~~ maximize chain length
15 while ~~substantially~~ minimizing the number of ~~storage~~ blocks read to support either ~~a~~the
16 subtraction method or ~~a~~the recalculation method,

17 performing read operations on the number of blocks ~~to be~~ read, and

18 calculating parity responsive to the number of blocks read and the data to be
19 written.

1 10. (Currently Amended) The method of claim 2, wherein ~~the identification of~~ identifying
2 the contiguous storage blocks is based at least in part on an available resource.

1 11. (Original) The method of claim 2 further comprising transmitting the block layout
2 information from a file system layer to a RAID layer.

1 | 12. (Currently Amended) The method of claim 2 wherein ~~the generating step~~ further
2 comprises:
3 making a first determination as to whether a storage block is unallocated;
4 making a second determination as to a current implementation of the plurality of
5 storage devices; and
6 generating the block layout information based at least in part on the first and the
7 second determinations.

1 13. (Currently Amended) The method of claim 2, wherein the I/O operation is one of a
2 | plurality of I/O operations and at least one of the plurality of I/O operations is a read
3 operation.

1 | 14. (Currently Amended) The method of claim ~~2~~ 5, wherein the chain length is a chain
2 length of a read operation for calculation of parity.

1 | 15. (Currently Amended) The method of claim ~~2~~ 5, wherein the chain length is a chain
2 length for a write operation for the data.

1 | 16. (Currently Amended) A method for managing storage of data in a storage system,
2 comprising:
3 maintaining a plurality of storage devices each having a plurality of storage
4 | blocks; and
5 | writing data to predetermined storage blocks of the plurality of storage blocks
6 across a plurality of stripes and to predetermined contiguous storage blocks within each
7 | storage device so as to ~~substantially~~ maximize chain lengths of the predetermined
8 contiguous storage blocks within each storage device and minimizing a number of read
9 operations for the calculation of error correction parameters across each stripe of the

10 | plurality of stripes by determining whether a parity subtraction method or a recalculation
11 | method requires a fewest number of read operations to calculate parity, and selecting the
12 | parity subtraction method or the recalculation method for parity calculation based on ~~the~~
13 | which method ~~that~~ requires the fewest number of read operations ~~to compute parity~~.

1 | 17. - 38. (Cancelled)

1 | 39. (Currently Amended) A storage system, comprising:
2 | a plurality of storage devices each having a plurality of storage blocks; and
3 | a storage manager in communication with the plurality of storage devices, the
4 | storage manager configured to write ~~writing~~ data to predetermined storage blocks across
5 | a plurality of stripes and to predetermined storage blocks within each storage device so as
6 | to substantially maximize chain length of the plurality of storage blocks by selecting as
7 | many ~~as~~-contiguous storage blocks within a single storage device while ~~substantially~~
8 | minimizing a number of read operations required for calculation of error correction
9 | parameters across each stripe of the plurality of stripes by determining whether a parity
10 | subtraction method or a recalculation method requires a fewest number of read operations
11 | to calculate parity and selecting a ~~the~~ parity subtraction method or ~~a~~ the recalculation
12 | method for parity calculation based on ~~the~~ which method ~~that~~ requires the fewest number
13 | of read operations ~~to compute parity~~.

1 | 40. (Currently Amended) A system for managing the storage of data, ~~the system~~
2 | comprising:
3 | a plurality of storage devices each having a plurality of storage blocks;
4 | a storage device manager in communication with the plurality of storage blocks;
5 | a block layout information generator in communication with the storage device
6 | manager and the plurality of storage blocks; and
7 | an error correction parameter calculator in communication with the plurality of
8 | storage blocks and the storage device manager,

9 wherein the storage device manager, in response to the block layout information
10 | from the block layout information generator, controls ~~the~~ execution of an I/O operation
11 | by identifying a plurality of contiguous storage blocks on a single storage device for use
12 | by the I/O operation so as to ~~substantially~~ maximize chain length within the single
13 | storage device while ~~substantially~~ minimizing ~~the a~~ number of read operations required
14 | for calculation by the error correction parameter calculator of error correction parameters
15 | across a stripe by determining whether a parity subtraction method or a recalculation
16 | method requires a fewest number of read operations to calculate parity for the I/O
17 | operations and selecting a the parity subtraction method or a the recalculation method for
18 | parity calculation based on ~~the~~ which method ~~that~~ requires the fewest number of read
19 | operations ~~to compute parity~~.

1 41 - 44. (Cancelled)

1 45. (Previously Presented) A method for managing storage of data by a server,
2 comprising:

3 receiving a request to write the data to a plurality of storage devices;
4 generating block layout information to determine which blocks within a plurality
5 | of blocks located in the plurality of storage devices are allocated ~~for storing data and~~
6 | which are unallocated;

7 identifying blocks within the plurality of blocks for use by a set of I/O operations
8 | ~~to store the data~~;

9 determining ~~the a~~ number of read operations needed to ~~compute~~ calculate parity
10 | for the data by ~~computing~~ calculating parity using a subtraction method ~~of computing~~
11 | ~~parity~~;

12 determining ~~the a~~ number of read operations needed to ~~compute~~ calculate parity
13 | for the data by ~~computing~~ calculating parity using a recalculation method ~~of computing~~
14 | ~~parity~~;

15 choosing either the subtraction method of ~~computing~~ calculating parity or the
16 | recalculation method of ~~computing~~ calculating parity by determining which ~~of these two~~

17 | methods requires ~~the~~ a fewer number of read operations, and choosing the which method
18 | that requires ~~requiring~~ the fewer number of read operations; and
19 | writing the data to the identified blocks, and ~~computing~~ calculating parity for the
20 | data using the ~~chosen~~ which method ~~of computing parity~~.

1 | 46. (Previously Presented) The method of claim 45, further comprising:
2 | choosing to either ~~firstly~~ maximize chain lengths of read operations for
3 | ~~calculation of~~ calculating parity or ~~secondly~~ choosing to place the data with a high degree
4 | of locality in the plurality of storage devices, by choosing the which method ~~which that~~
5 | requires the ~~fewest~~ fewer number of read operations ~~in computing parity for the data~~.

1 | 47. (Currently Amended) A method for managing storage of data by a server,
2 | comprising:
3 | receiving a request to write data to a plurality of storage devices;
4 | generating block layout information to determine which blocks within a plurality
5 | of blocks located in the plurality of storage devices are allocated ~~for storing data and~~
6 | which are unallocated;
7 | identifying blocks within the plurality of blocks for use by a set of I/O operations
8 | to store the data; and
9 | ~~selecting~~ determining, in response to the block layout information, whether to
10 | ~~substantially minimize the~~ a number of read blocks or whether to ~~substantially~~ maximize
11 | chain lengths of read blocks based on which method requires a fewer number of read
12 | operations, and
13 | implementing ~~the~~ a selection, during the writing of the data to the plurality of
14 | storage devices, responsive to the block layout information, and responsive to whether
15 | ~~substantially~~ minimizing the number of read blocks or substantially maximizing chain
16 | lengths of read blocks requires the fewer number of read operations.

1 48. (Currently Amended) The method of claim 47, further comprising:

2 in response to selecting to ~~substantially~~ minimize the number of read blocks,
3 determining whether to calculate parity based on ~~the a~~ subtraction method or ~~the a~~
4 recalculation method ~~by determining based on~~ which method requires the fewer number
5 of read operations, ~~and selecting the method which requires the fewer number of read~~
6 ~~operations;~~ and

7 performing the write operation and calculating the parity using ~~the which~~ parity
8 calculation method ~~requiring~~ requires the fewer number of read operations.

1 49. (Currently Amended) The method of claim ~~48~~ 47, further comprising:

2 in response to selecting to ~~substantially~~ maximize chain lengths of read blocks,
3 deciding which storage blocks to read to ~~substantially~~ maximize chain lengths while
4 minimizing the number of storage blocks read to support either the subtraction method or
5 the recalculation method ~~of parity calculation;~~ and

6 performing the write operation and calculating the parity using ~~the which~~ parity
7 calculation method ~~requiring~~ requires the fewer number of read operations.

1 50. (Currently Amended) A method for managing storage of data by a server,
2 comprising:

3 receiving a request to write data to a plurality of storage devices;

4 generating block layout information to determine which blocks within a plurality
5 of blocks located in the plurality of storage devices are allocated ~~for storing data~~ and
6 which are unallocated;

7 identifying blocks within the plurality of blocks for use by a set of I/O operations
8 to store the data;

9 testing to either maximize chain lengths of read operations for calculation of
10 parity, or to place the data with a high degree of locality in the plurality of storage
11 devices, the testing ~~having the steps~~ comprising,

12 determining, for both maximizing chain length and placing the data with ~~a the~~
13 high degree of locality, ~~the a~~ number of read operations needed to ~~compute~~ calculate

14 parity for the data, by ~~computing-calculating~~ parity using both ~~the-a~~ subtraction method
15 of ~~computing-calculating~~ parity and ~~the-a~~ recalculation method of ~~computing-calculating~~
16 parity;

17 firstly ~~first~~ choosing to either maximize chain lengths of read operations for
18 calculation of parity or to place the data with ~~a-the~~ high degree of locality in the plurality
19 of storage devices, and after ~~this-the~~ first choice, secondly choosing either the subtraction
20 method of ~~computing-calculating~~ parity or the recalculation method of ~~computing~~
21 ~~calculating~~ parity by determining which of these methods requires ~~the-a~~ fewest number of
22 read operations,

23 choosing ~~the-which~~ method ~~requiring-requires~~ the fewest number of read
24 operations of ~~computing-calculating~~ parity of the data; and

25 writing the data to ~~the~~ identified blocks, and ~~computing-calculating~~ parity for the
26 data using the ~~chosen-which~~ method of ~~computing~~ parity.

1 51. (Currently Amended) A computer readable media, comprising:

2 said computer readable media containing instructions for execution on a processor
3 for a method of managing storage of data in a plurality of storage devices, each storage
4 device having a plurality of blocks for storing data, the method ~~having comprising~~,
5 generating block layout information; and

6 in response to the block layout information, controlling ~~the~~ execution of an I/O
7 operation by identifying a plurality of contiguous storage blocks on a single storage
8 device for use by the I/O operation so as to ~~substantially~~ minimize ~~the-a~~ number of read
9 operations needed for calculation of error correction parameters across a stripe by
10 determining whether a parity subtraction method or a recalculation method requires a
11 fewest number of read operations to calculate parity for the I/O operations and selecting
12 at the parity subtraction method or at the recalculation method for parity calculation based
13 on the-which method that requires the fewest number of read operations to compute
14 parity.